

## THE RADIOLOGICAL STATUS OF THE BIKINI PEOPLE

## A Summary Report

This report summarizes the events with which I am familiar concerning the radiological findings on the people of Bikini and the events necessitating their removal again.\*

## A. BACKGROUND

## 1. Evacuation of the People and Early Surveys

In 1946, in preparation for the atomic bomb test program (Operation Crossroads), the 166 Bikini natives were moved first to Rongerik atoll, which proved to have insufficient natural resources, then briefly to Kwajalein, and finally in November 1948 to Kili island in the southern Marshalls. This island has been unsatisfactory in many ways, particularly since it lacks a lagoon to furnish the type of fish to which the Marshallese were accustomed. The forced change in diet contributed markedly to the inability of these people to adjust to Kili island. In the 10 years after the atomic bomb testing ended with the moratorium in 1958, Bikini had become overgrown with dense vegetation. Brief radiological surveys of the island had been carried out on several occasions and a complete survey was done in 1964, at which time it was decided that the safety of the people returning permanently to the area might be endangered. A detailed survey was made in April-May 1967 at the request of the Secretary of the Interior. The gamma dose that time was about the same as in the U.S. in the beach areas of the island, but higher in the interior. Pandanus, coconut meat and milk, as well as coconut crabs all contained substantial amounts of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ .

## 2. Ad Hoc Committee Meeting

The AEC convened an ad hoc committee consisting of 8 scientists to consider if Bikini atoll was suitable for human habitation with regard to radiological hazards. Members and associates of the 1967 survey team presented their findings and also the committee was briefed by Dr. Jack Tobin, an anthropologist, who was expert in Marshallese culture. Dr. P. F. Gustafson presented a summary report of the radiological data based on living patterns on Bikini Island. He concluded that, "it is unlikely that the whole-body exposure or the exposures to specific organs including bone will exceed 4 rads in 5 years, 15 rads in 30 years, or 30 rads in 70 years". After reviewing the available data, the ad hoc committee concluded that, "the exposure to radiation that could result from repatriation of the Bikini people did not offer a significant threat to their health and safety." (See attached copy of report.) They recommended a number of measures to

\* In view of my retirement in several months, I thought it might be desirable to write this brief report.

reduce radiation exposure. In retrospect, as a member of the committee, I believe that, based on the data available at that time, the decision to allow the people to return to Bikini was justified. It should be remembered that radiation measurement techniques then were not as sophisticated as those available today; that the surveys of Bikini were far less extensive than those subsequently carried out at Enewetak atoll; and that exposure pathways of radioactive materials in the environment are better understood at this time. The recommendation regarding continued regular radiological surveillance of the returning people, to which I was assigned the responsibility, was a very important one since in this way any unexpected findings with regard to body burdens of radionuclides could be detected and corrective measures immediately instituted. It was because of this careful monitoring that the recent unexpected rise of body burdens of the people living on Bikini was detected, unfortunately necessitating the re-evacuation of the people.

Since there were few food plants growing on Bikini for evaluation at the time of the 1967 survey, there was uncertainty regarding the extent of the radioactive uptake to be expected in the newly planted food crops (pandanus, coconuts, etc.). Thus the committee recommended that the first food crops be grown on Eneu and the first village settlement be made at that site. This was not carried out, probably because many of the people did not own land on Eneu and wanted their village established on Bikini Island. It was also recommended that several inches of topsoil be removed around the newly planted pandanus, that the village area be covered with clean coral and that the coconut crab population be reduced.

It should also be pointed out that though regular personnel monitoring of the people and environment was recommended, it was not the intent of the committee that medical examinations, as such, be conducted since expected exposures from living on Bikini would be so low that such examinations would not be indicated. Therefore the medical teams passing through Bikini have held sick call and medical examinations for humanitarian reasons, but not for the purpose of checking any possible radiation effects.

On August 12, 1968, President Johnson announced that the people of Bikini could return to their home atoll and plans for redevelopment and resettlement were initiated with responsibilities assigned to AEC, DOI/TT and DOD for various aspects of the program. Shortly after this, officials from the TT and AEC visited Kili and explained the recommendations of the ad hoc committee and the plans for repatriation. Later I also visited Kili and briefed the people on the recommendations of the committee and discussed our plans for personnel monitoring. At that time we collected baseline urine samples for radiochemical analyses.

### 3. Cleanup and Reconstruction at Bikini

The cleanup was accomplished during the latter half of 1969. Almost the entire island of Bikini was bulldozed to rid the island of scrub growth. Scrap metal, etc., was removed. This was followed by planting many thousands of coconut trees, pandanus and breadfruit and construction of 40 concrete block houses. At this time some 30 TT agricultural and construction workers lived in a tent work camp on Enue and commuted to Bikini 7 miles away.

By 1972 several Bikini families had moved to the atoll and along with workmen moved over to Bikini Island to live. They first lived in temporary housing left over from the testing program, but moved into the concrete houses several years later when they were completed. Since that time several other families moved to the atoll and the number of people increased from 60-70 to 143 (many new children) at the time of the survey in 1978. In August 1978 they were removed from the island down to Kili again.

#### 4. Environmental Monitoring

During the cleanup operation on Bikini another radiological survey was conducted. The results of this survey showed that radiation levels were not very different from those reported in the 1967 survey. Following this a number of surveys were made at Bikini, plotting external radiation levels and radiological analyses of air, soil, water, plants and marine life. I will not attempt to summarize the results in this report.

These surveys were carried out by various groups including teams of scientists from the University of Washington, Lawrence Livermore Laboratory and a comprehensive group from Brookhaven National Laboratory. Plans to build homes in the interior of the island in 1975 resulted in more extensive surveys on Bikini which showed levels in the interior of the island to be prohibitive as home sites. It was also found that higher levels of activity than had been estimated were present in pandanus and breadfruit and resulted in restriction of consumption of these homegrown products. These findings were discussed with the people of Kili by U.S. officials and caused considerable unrest and unhappiness among these people, resulting in unfortunate accusations against us in the light of our earlier statements about the radiological safety of the island. This also resulted in a threatened suit against the U.S. with plans to have another medical team examine the people, etc. The threat of this suit soon abated when the lawyers were assured that there would be an aerial survey of all the northern Marshalls, including Bikini Atoll, which is now in progress.

#### 5. Personnel Monitoring

Urinalyses: Collections have been made annually on people living on Bikini for radiochemical urine analyses. These analyses were done by the Health and Safety Laboratory of DOE until 1977 and in DOE-sponsored laboratories at Hanford, Los Alamos, and more recently at BNL. The principal radiological isotopes measured were  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  and, more recently, measurements of  $^{239,240}\text{Pu}$ . These analyses were formally coordinated by our Medical Department here at BNL but recently responsibility has been transferred to a group in our Safety & Environmental Protection Div. under Dr J. Naidu.

Gamma Spectrographic Analyses: Whole-body gamma counting (body measurement for  $^{137}\text{Cs}$ ) has been carried out using a "shadow shield" type of facility using radiation-free lead bricks, which we had constructed for our surveys at Rongelap and Utirik. This facility has been set up in an airconditioned trailer aboard ship. Counts on the Bikini people were carried out in 1974 and 1977 under the direction of Dr. S. Cohn (Medical Department) and in 1978 by Messers R. Miltenberger and N. Greenhouse (Safety and Environmental Protection Division) at BNL.

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## B. RESULTS OF PERSONNEL MONITORING

### 1. 1970-1974:

During this period both urine and gamma spectrographic analyses showed body burdens of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  in people living at Bikini to be well below the maximum permissible body burdens and about  $\frac{1}{4}$  of the levels of the Rongelap people who were also measured during that period. The annual dose to the bone marrow in the Bikini people was estimated to be about 20-22 mrad from the internal exposure. This indicated that they had largely been subsisting on food furnished from the TT, since availability of locally grown foods was minimal. Coconuts, breadfruit and pandanus had not yet reached maturity.

At the time of the visits of our team to Bikini, the people were informed about our findings. They were told of the presence of radioactive Sr and Cs and were advised not to eat locally grown foods. They were also advised about the presence of low levels of Pu in their urine in 1975. At a meeting with the people in 1977 they admitted they were eating some foods grown locally. During this period we were able to report to the people that levels of radiation exposure on Bikini were comparable to that of people living in some other areas in the world, such as those living at high altitudes (e.g. Denver, Colorado), and that no detectible effects were noted in people who lived in these areas.

### 2. The Plutonium Finding:

In 1975 the Health and Safety Laboratory reported that urine samples from the Bikini people showed the presence of low levels of  $^{239,240}\text{Pu}$ . It was known that low levels of Pu were present on Bikini in the soil, catchment water, plants, etc. Since the levels reported were at the lower range of detection ( $0.009 \pm 0.002$  pCi/liter) and the standard error of counting at these levels was large, there was some doubt that the measurements were significant. Contamination of the urine samples was considered a possibility. A calculation of body burden at this level of Pu excretion revealed that the isotope could not exceed 10% of the MPBB. Although levels are very low, diet seems to be the most probable source of Pu in urine. Samples of soil on Bikini had shown Pu to be less than the 40 pCi/g established as the upper level for the Enewetak survey. The Transuranium Task Group (advisory group to the AEC) was asked to review the Bikini data. Dr. Bair, Chairman of the Committee, reported that, "if taken at face value, the risk [to the people living on Bikini] would be very small".

Recent samples of Bikini urines (1977-1978) analyzed at the Los Alamos Laboratory, have revealed very low levels of Pu. Several months ago we arranged for the Health Aide from Bikini, who was in Washington, DC, for Congressional Hearings, to have Americium-241 counts done in a special facility at NYU by Dr. N. Cohen. (Americium is known to be present with Pu.) The results were negative for Americium and presumably also for Pu. Thus the low levels of Pu present in the people are probably not radiologically significant.

### 3. 1975-1978:

During this period an increase in body burdens of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  were detected and gamma spectrographic analysis of the people on the island in 1977 showed a sharp rise, an elevenfold increase in  $^{137}\text{Cs}$ . (See Table 1). Due to this finding it was suggested to the TT that complete food subsidization of the Bikini people might help reduce the consumption of locally grown foods and thus reduce their exposure. This was carried out and also, as recommended, increased supplies of powdered milk were sent to the island to increase their dietary calcium and thus help reduce the absorption of  $^{90}\text{Sr}$ .

By April 1978 the body burdens of  $^{137}\text{Cs}$  showed a further increase of twofold. By this time coconuts had reached maturity and had become plentiful and to a much lesser extent, pandanus and breadfruit were available. It was apparent that in spite of the increased food subsidy the people were eating more locally grown foods. At the time of the 1978 survey, a water shortage had become acute and the people admitted having drunk coconut milk for this reason. They were admonished again to refrain from eating foods grown on Bikini and it was suggested that they get coconuts from Enue island on a regular basis for consumption. (It was not known at that time that the coconuts on Enue had also been found to have higher  $^{137}\text{Cs}$  levels than previously reported.)

Table I (Miltenberger et al.) shows the increase in mean levels of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  in the Bikini people since 1974. Preliminary data on  $^{90}\text{Sr}$  in the 1978 urines indicate that levels of this isotope did not change markedly and did not parallel the increase in Cs. This may be a favorable effect of the dietary calcium supplement. A marked increase in body burdens of  $^{137}\text{Cs}$  was noted (to a mean level of about 2  $\mu\text{Ci}$ ). The additional dose from  $^{90}\text{Sr}$  appeared to be small. Rough estimates indicate that the whole body dose (internal plus external) as measured in 1978 would average near or slightly above 500 mrad/yr, which is at or slightly above the maximum permissible level. These findings prompted the TT to remove the people from Bikini. This was accomplished in September of 1978. Their forced exile is a bitter disappointment to the people and they still have hopes of returning to their atoll to live, even if only to Enue.

### 4. Medical Examinations:

At the time of the Bikini survey in April 1978, our entire medical team was present on Bikini for two days and we offered to carry out complete medical examinations on all who so desired. About 140 people -- men, women, children and babies -- came aboard the ship for exams. Only three people living on the island were not examined. These examinations included those of children by a pediatrician, pelvic examinations in women by a gynecologist, electrocardiographic study on people over 40 yrs of age, thyroid examinations and blood and urine checks. The people appeared to be generally in a good state of health and nutrition (equal to that of other islanders examined) and no thyroid disorders or evidence of malignancy was noted. There were no findings which could be ascribed to radiation effects. The people were cooperative and friendly and most grateful for the examinations.

### C. FUTURE PLANS:

The negative findings on the 1978 medical examinations for the Bikini people with regard to possible radiation effects would not preclude such effects developing later due to the latent period for such effects. However, the results of the exams certainly refute the rumors circulated in the news media that the Bikini people have developed cancer and thyroid tumors as a result of living on the island.

One can estimate roughly the risk of radiation effects in the 143 people who were on Bikini in 1978. Assuming that they had all been there since 1970 and received the average estimated integrated total dose of 2.6 rads for the period, based on known radiation-induced risk data, one would expect only about 0.005 total cases of leukemia to develop in that population as a result of their radiation exposure. Similar low risk estimates would apply to other possible malignancies. There would be no specific thyroid effects as noted in the Rongelap people, since the Bikini people have not been exposed to radioiodides or other isotopes which concentrate in the thyroid gland. One can therefore state that it is extremely unlikely that any radiation effects, somatic or genetic, will be detected in this group.

What about the need for future medical examinations in the Bikini people now that they have been removed to noncontaminated islands? Since, as pointed out above, radiation effects are unlikely to be detected, the need for further medical examinations is not indicated based on possible radiation effects associated with such low doses. However, from our experience with the Rongelap, Utirik and Bikini people, it is clear that the psychological effects of living on contaminated islands (fear of development of radiation effects; association of nearly all ailments with radiation exposure) indicate that regular medical checkups on both Bikini and Eniwetak people who have lived or are living on contaminated islands are most desirable. The reassurance to the people by a group of doctors will do much to help them maintain a healthy mental attitude toward the problem and in addition, they will accrue benefits of more complete health care which they certainly deserve. When cancer develops in these people, which will occur as in any population, U.S. agencies may have to face court claims (such as are now showing an alarming increase in the U.S.) and the dilemma of disproving a correlation of such diseases with low dose radiation exposure will be a discouraging one.

Radiation monitoring of body burdens of radionuclides in those people who have lived in Bikini should be continued for a time. Again, spectrographic analyses (whole body counts) should not be necessary for more than one year, since the present  $^{137}\text{Cs}$  levels should be reduced by over three biological half lives by that time, assuming no further intake of  $^{137}\text{Cs}$ . Radiochemical urinalyses of  $^{90}\text{Sr}$  and Pu should continue for several years. Living on an uncontaminated island should help give a definitive answer regarding possible Pu body burdens by ruling out the possibility of contamination of samples.

From my 25 years' involvement with the radiation problems among the Marshallese of Rongelap, Utirik and Bikini, I have developed a great deal of affection for these people and have been greatly saddened by their forced exiles and the effects of radiation exposure on the Rongelap people. I can only hope that we will do everything possible to assure that their future will be brighter than their past has been.

Robert A. Conard, M.D.

September 20, 1978

Attach:

TABLE 1

## Whole Body Dose in the Bikini People from External and Internal Radiation

(R. P. Miltenberger, F. T. Cua)

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|                           | 1970<br>mRem           | 1971<br>mRem           | 1972<br>mRem           | 1973<br>mRem           | 1974<br>mRem           | 1975<br>mRem           | 1976<br>mRem            | 1977<br>mRem            | 1978<br>mRem            | 8 Year<br>Total |
|---------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|-------------------------|-----------------|
| (1)<br>External<br>Dose   | 235                    | 227                    | 219                    | 213                    | 206                    | 200                    | 195                     | 190                     | 183                     | 1868            |
| (2)<br>Internal<br>Cs-137 | (0.105 $\mu$ Ci)<br>18 | (0.105 $\mu$ Ci)<br>18 | (0.105 $\mu$ Ci)<br>18 | (0.105 $\mu$ Ci)<br>18 | (0.105 $\mu$ Ci)<br>18 | (0.268 $\mu$ Ci)<br>45 | (0.612 $\mu$ Ci)<br>102 | (1.122 $\mu$ Ci)<br>187 | (2.073 $\mu$ Ci)<br>346 | 770             |
| (3)                       |                        |                        |                        |                        |                        |                        |                         |                         |                         |                 |
| (4)<br>Internal<br>Sr-90  | (2.3pCi/d)<br>2        | (3.4pCi/d)<br>2        | (5.9pCi/d)<br>4        | (9.4pCi/d)<br>8        | (4.2pCi/d)<br>4        | (7.0pCi/d)<br>6        | (7.0pCi/d)<br>6         | (7.0pCi/d)<br>6         | (10.6pCi/d)<br>8        | 46              |
| Total                     | 255                    | 247                    | 241                    | 239                    | 228                    | 251                    | 303                     | 383                     | 537                     | 2684            |

- (1) Initial data were taken from 1975 UCRL Report 51879 Rev. 1 living pattern #2, adult population only.
- (2) Data taken from 1974, 1977 and 1978 WBC reports. Body Burdens of 1970-1974 assumed to be constant at the 1974 level due to lack of data on individuals prior to 1974.
- (3) Body burdens for  $^{137}\text{Cs}$  in the years 1975 and 1976 were obtained from interpolation between 1974 and 1977 data.
- (4) Available information does not permit calculation of an average  $^{90}\text{Sr}$  body burden for the Bikini population. A range of body burden values for the average individual can be calculated by varying the assumptions used on the known parameters. Reported values provide one result obtained by assuming constant continuous uptake occurred during sampling and that constant continuous uptake of  $^{90}\text{Sr}$  existed prior to sampling.



REPORT OF THE AD HOC COMMITTEE TO EVALUATE  
THE RADIOLOGICAL HAZARDS OF RESETTLEMENT OF THE BIKINI ATOLL

The Committee was convened to consider the question of whether the Bikini Atoll is safe for human habitation with respect to the radiological hazard. The detailed history of the various relocations of the Bikini natives is described in the appended material provided by Mr. Tobin (Appendix I)\*.

We have examined the documents listed in Appendix II. In addition, we spent one and one-half days in detailed discussions with members of the 1967 Bikini Survey Team and other experts as shown in Appendix III. On the basis of the information provided, we have reached the following conclusions and recommendations:

1. The exposures to radiation that would result from the repatriation of the Bikini people do not offer a significant threat to their health and safety.
2. Such exposure may and should be further reduced by the following simple measures:
  - a. Restrict rehabilitation for the present to the islands of the Bikini-Eneu complex. (Appendix IV)
  - b. Establish the first village and immediate food crops on Eneu. No radiological precautions will be needed on Eneu because of its very low contamination level. (Appendix V)
  - c. Any village construction on Bikini Island should involve the covering of the site with coral rock as is the local custom.
  - d. Radioactive scrap metal should be removed from the islands adjacent to former shot sites.
  - e. The population of land crabs should be sharply reduced because of their high content of strontium 90.
  - f. If pandanus trees which produce edible fruit are planted on Bikini Island, two inches of topsoil should be removed from the planting sites. The area of removal from each site should be equal to the area covered by the crown of mature trees.

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3. Determinations should be made of body burdens of cesium 137 and strontium 90 at the end of the first year of residence on the Atoll and as appropriate thereafter. Baseline surveys prior to relocation would be desirable. Resurveys of environmental radiation levels on the Bikini Atoll and estimates of radionuclides in food should be made periodically. These surveys will provide a continual check of the radiation status of the people and environment and will help form a basis for decision as to the time of rehabilitation of islands outside of the Bikini-Eneu complex.
4. Special efforts should be made to ensure a balanced and adequately nutritious diet. For example, a dietary supplement of powdered milk would materially reduce strontium 90 uptake by relieving the calcium deficiency usually associated with their diet.

Respectfully submitted:

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John B. Storer, Deputy Director of AEC's Division of Biology and Medicine, Washington, D. C.

Paul Tompkins, Executive Director, Federal Radiation Council, Washington, D. C.

Shields Warren, Scientific Director, Cancer Research Institute, New England Deaconess Hospital, Boston, Mass.

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\*A limited number of copies of the appendices to the Committee report are available on request. They are:

- Appendix I - "Preliminary Anthropologist's Report -  
Bikini Atoll Survey 1967," by Jack A. Tobin
- Appendix II - List of Documents Examined" by Committee
- Appendix III - List of Members and Associates of the  
Survey Team
- Appendix IV - Map of Bikini Atoll
- Appendix V - "Brief Summary of the Radiological Status  
of Bikini Atoll," by Philip F. Gustafson

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